J. Perinat. Med.
12 (1984) 173

Shoulder-out immersion in pregnant women

R. C. Goodlin, K. L. Engdahl Hoffmann, N. E. Williams, P. Buchan*

Department of Obstetrics and Gynecology, University of Nebraska, Medical Center, Omaha, Nebraska, USA
* Ladies-in-Wading, Inc., Omaha, Nebraska, USA

Normal pregnancy outcome is associated with a significant increase in plasma volume and red cell mass. By contrast, many complications of pregnancy (hypertension or toxemia, fetal growth retardation) are associated with a relative maternal hypovolemia and sometimes with an increase in extravascular fluids and peripheral resistance. Limited success in treating complications of pregnancy (toxemia, IUGR) has been achieved by efforts to expand plasma volume [1, 2] GAUER and HENRY (1961) concluded that "head-out body immersion is the investigational tool of choice for the study of the effects volume expansion". Apparently no other technique assures continuous increase in plasma volume, particularly central plasma volume expansion [3].

Water immersion, as a therapeutic and healing agent, was used by ancient civilizations and hydrotherapy is still an important part of the armentarium of sports medicine. Water immersion is also widely used as a research technique of simulating weightlessness. According to EPSTEIN, Hartshorne in 1847 recognized the diuretic response to immersion and proposed that the heart possessed volume receptors [4]. Its medical application began with BAZETT and co-workers' (1924) use of immersion to study renal function [5]. Cirrhotic patients with ascites and/or edema which is unresponsive to conventional therapy will all have diuresis and most will have natriuresis after undergoing water immersion [6]. KASS has recently shown that the application of lower body positive pressure suits in baboons also results in diuresis and natriuresis [7]. Reported here are attempts to evaluate water immersion and lower body positive pressure as a diuretic and natriuretic agents in pregnant women.

1 Methods and materials

1.1 Positive pressure leg sleeves

Lower body positive pressure was studied in 11 pregnant women in their third trimester being treated in the University Hospital for chronic hypertension and/or preeclampsia. Vital signs (blood pressure, pulse, urine output) was measured every 8 hours. Blood hematocrit, hemoglobin concentrations and urea nitrogen were determined daily. Daily urinary sodium and potassium excretion were measured. As only a pressurized calf sleeve (Venodyne Intermittent Compression System) designed to prevent thrombotic embolism was approved by the hospital's research community, this was applied for 72 hours with the subject at bed rest. With the pressure sleeve on the subjects' calves, an automated pressure unit with pressures up to 40 torr was cycled at 2 minute intervals.

1.2 Sitting immersion

Water immersion in a HUBBARD tank for 120 minutes was initially studied in 4 women at

28–34 weeks of pregnancy who were hospitalized for hypertension. The HUBBARD tank allows a water height of 18″ in which the subject sits on a special stretcher with water to level of breast. The water temperature was agitated and at 35 °C. The same vital signs, blood and urine tests were obtained as in part A.

1.3 Shoulder-out immersion exercise

Forty-two non-hospitalized pregnant women, participating either in a commercial antenatal water exercise plan (Ladies-in-Wading) or in the University's plan were asked to volunteer for physiologic studies. Three subjects had a diagnosis of mild-moderate preeclampsia and 4 had a diagnosis of chronic hypertension. Vital signs and urine samples were obtained prior to immersion and after 60 minutes of exercising immersion. The exercises consisted of mild calisthenics in standing position with water (34 °) to approximately their nipple line.

2 Results

Subjects registered at the University signed an informed consent according to rules of the Institutional Review Board. Those 36 subjects registered at "Ladies-in-Wading" signed its release form.

2.1 Lower body positive pressure

Of 11 subjects studied, there were no significant differences in mean blood pressures, hematocrit/hemoglobin or BUN values when pressure stockings were applied. Urine output increased greater than 30% in 2 out of the 11 subjects, but declined

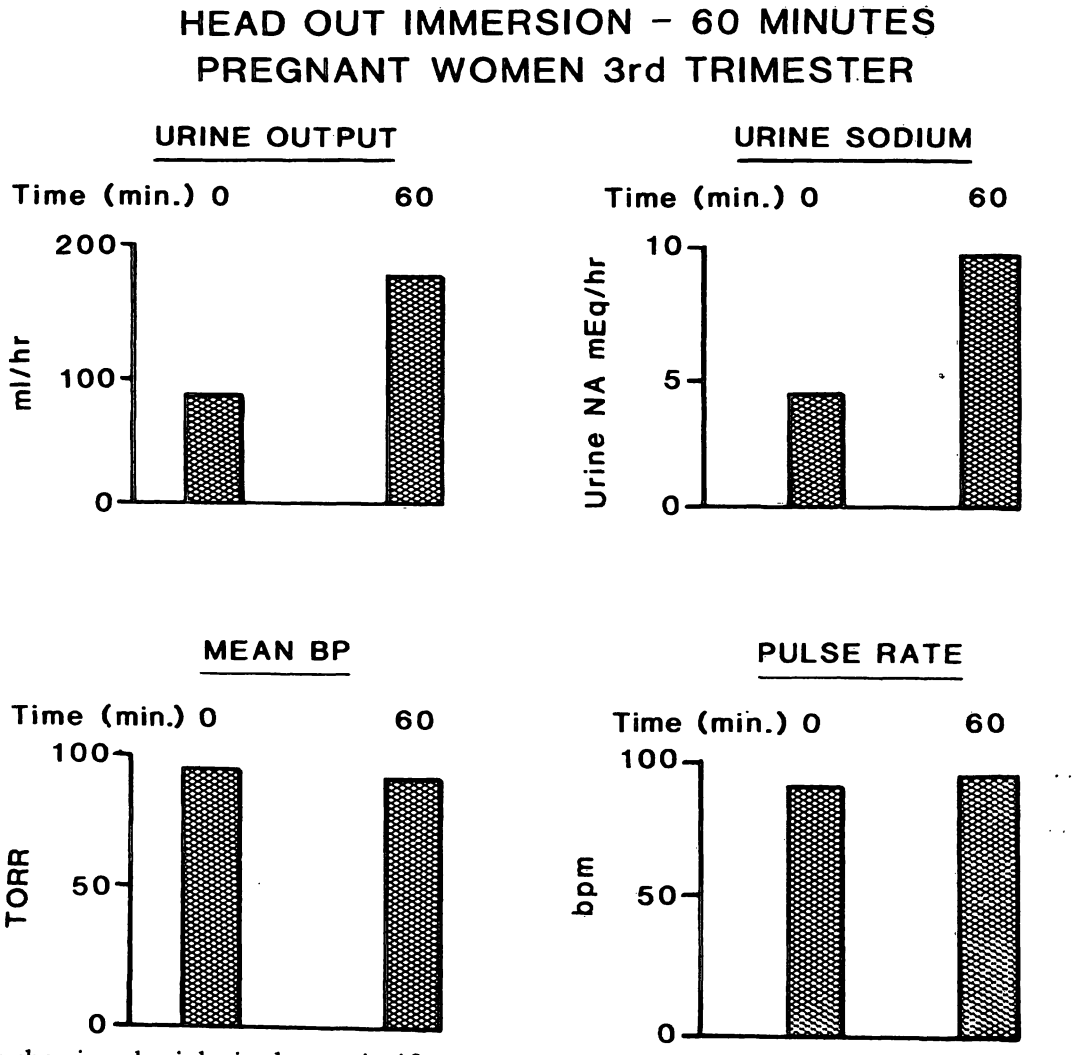

Fig. 1. Bar graph showing physiologic changes in 42 pregnant women undergoing 141 shoulder-out immersions.

in 3 out of the 11. It was concluded that positive pressure calf sleeves had no significant effects on plasma volumes, renal function or mean blood pressures. The sleeves were not well received by the subjects.

2.2 Immersion in the HUBBARD tank

Three out of 4 had mean blood pressure decreases of more than 10 torr after 2 hours of immersion. Two had increases in pulse of greater than 10 bpm. There were otherwise no significant changes.

2.3 Exercising and shoulder-out immersion

Forty-two subjects were studied on two or more occasions. Eighteen were studied for 3 to 8 weeks with immersion twice a week. There were no significant changes in weights or pulse rates before or after the one hour of immersion. There was no significant change in blood pressure or pulse. Blood pressures decreased 5 or more torr in 68 out of 141 immersions and increased more then 5 torr in 16 immersions. Of the 42 subjects, only one discontinued the study because of an increase in blood pressure. Two subjects whose blood pressures remained unchanged while participating in immersion two times per week from 33 to 38 weeks of pregnancy, developed moderate to severe preeclampsia after discontinuing the immersion therapy.

The significant findings were limited to urine output. Urine output increased significantly as did urinary sodium (Fig. 1). Urine output the hour prior to immersion was 92 ± 37 ml/hr and after immersion was 185 ± 52 ml/hr with $P < 0.02$. Urinary sodium increased from 3.8 ± 2.1 mEq/hr to 9.4 ± 4.8 ($P < 0.02$) after one hour of immersion exercise. Those subjects with significant ankle edema had the largest diuresis and natriuresis with subjects weight X degree of edema correlating ($r = +0.65$) with urinary output. Urinary output after immersion correlated ($r = -0.58$) inversely with urine sodium content. The three subjects with preeclampsia had the greatest urinary sodium output (21–34 mEq Na per hour) after immersion. Urine output post-immersion was also inversely correlated ($r = -0.82$) with urine osmolality.

Many subjects reported marked diuresis post-immersion with those having significant edema that their shoes and rings fit better. Five subjects placed dry cotton balls high in their vaginas prior to immersion. Post-immersion, the cotton balls were dry in 4 subjects. No adverse reactions were reported from immersion with the subjects continuing to pay with their own funds for the exercise immersion antenatal classes.

3 Discussion

Head-out immersion (HOI) of normal subjects is associated with a redistribution of approximately 750 ml's of blood to the thorax creating a relative central hypervolemia [4]. There is general agreement that the increase in thoracic blood volume and the accompanying absolute increase in plasma volume provides the stimuli for the renal responses during immersion. The increase in plasma volume represents mobilization of extravascular fluid and the increased thoracic volume represents a cephalad redistribution of blood from the lower body [8, 9]. The hemodynamic and renin-aldosterone responses of HOI have been reported to be equivalent to those produced by a 10% extracellular volume expansion with two liters isotonic saline [10]. There is also an increase in percent cardiac output to vital organs in non-pregnant monkeys treated with immersion and a general decrease in peripheral resistance [4, 11]. The increased natriuresis, diuresis and free water clearance associated with HOI perhaps occurs because of the increased intracardiac filling pressure and cardiac output with direct stimulation of left atrial pressure receptors and/or release of an atrial "peptide" with natriuretic actions [12, 13]. The natriuresis induced by either HOI or lower body positive pressure is blocked by dopamine, is independent of changes in glomerular filtration rate, and persists when a mineralocorticoid hormone is administered in pharmacological doses [14]. There then are two distinct renal effects of HOI or lower body positive pressure. A diuresis which can be maintained for longer than three days with adequate hydration and a natriuresis

which becomes diminished after 24 hours of continuous LBPP or HOI. During head-out immersion there is no change in the total oxygen consumption [15].

Bed rest has long been recommended for women with complications of pregnancy and is associated with a transfer of approximately 500 ml's of blood to the thorax with a corresponding increase in cardiac and renal functions and a corresponding natriuresis and diuresis. However, unlike immersion, these renal responses of bed rest soon become attenuated. The literature suggests that HOI is perhaps 50–100% greater in effect than is bed rest, with HOI having an almost instantaneous (approximately 7 seconds) and prolonged effect in increased central plasma volume [4].

Apparently head-out immersion has not been studied in pregnant women. Shoulder-out immersion appears to be an excellent tool to study cardiac and renal changes after volume expansion during pregnancy as well as to evaluate immersion's role as a possible prophylactic technique for the prevention of complications of pregnancy. Repeated use of immersion may also be a therapeutic tool in toxemias of pregnancy as the principle physiologic effects of immersion appear to counteract the abnormal findings in toxemia. Abnormal responses to HOI (degree of natriuresis, diuresis or BP changes) may distinguish those destined to remain as mild toxemia from those destined to severe toxemia.

In this study, the subjects were not on a standard sodium diet or fluid intake. Nevertheless, it does appear that shoulder-out immersion in pregnant women, as in the non-pregnant, is associated with significant natriuresis and diuresis. This study differed from those in the literature in that the subjects were pregnant, upright, immersion was only to shoulders, and the water temperature was lower. More detailed studies are required to determine whether immersion will be useful in the pregnant subject.

Our experience suggests that immersion to shoulders is well tolerated and enjoyed by pregnant women. Use of lower body positive pressure suits could be associated with air embolism in pregnant women [16]. The positive pressure leggings were not tolerated for prolonged usage by our subjects, indicating that frequent, but brief immersion in swimming pools is the optimal technique for obtaining central blood volume expansion during pregnancy.

Summary

In the laboratory, water immersion or lower body positive pressure produces significant diuresis and natriuresis. Shoulder-out immersion appeared to induce significant diuresis and natriuresis in 42 pregnant women who were exercising in swimming pools. Lower body positive pressure (pressure calf sleeves) or HUBBARD tanks (bathtubs) was not associated with increased renal function. In selected pregnant women with abnormal water distribution, shoulder-out immersion may prove to be effective therapy.

Keywords: Diuresis, edema, natriuresis, pregnancy, shoulder-out immersion.

Zusammenfassung

Tauchbäder bis zu den Schultern bei schwangeren Frauen
Im Labor treten bei Tauchbädern und bei positiven Drücken auf untere Körperabschnitte eine signifikante Diurese und Natriurese auf. Ein Eintauchen bis zu den Schultern während gymnastischer Übungen im Swimmingpool schien bei 42 Schwangeren eine signifikante Diurese und Natriurese zu induzieren. Nach positiven Drücken auf untere Körperabschnitte (Druckmanschetten an den Waden) und Wannenbädern war die Nierenfunktion nicht gesteigert. Bei bestimmten Schwangeren mit einer abnormen Wasserverteilung könnte das Eintauchen bis zu den Schultern eine effektive Therapie darstellen.

Schlüsselwörter: Diurese, Natriurese, Ödeme, Schwangerschaft, Tauchbad bis zur Schulter.

Résumé

Immersion sous les épaules chez les femmes enceintes
Au laboratoire, l'immersion dans de l'eau ou des pressions positives sur la partie inférieure du corps entrainent une diurèse significative et une natriurèse. L'immersion sous les épaules induit une diurèse significative et une natriurèse chez 42 femmes enceintes qui pratiquent la

natation en piscine. Des pressions positives sur la partie inférieure du corps (pression par un manchon au niveau du mollet) ou les bains de HUBBARD ne sont pas associés à une augmentation des fonctions rénales. Dans une population sélectionnée de femmes enceintes présentant une anomalie de distribution hydrique, l'immersion sous les épaules peut être essayée comme thérapeutique efficace.

Mots-clés: Diurèse, grossesse, immersion sous les épaules, natriurèse, oedème.

Bibliography

[1] LONGO, L.: Maternal blood volume and cardiac output during pregnancy. Am. J. Phys. 243 (1983) R720
[2] GOODLIN, R., M. QUAIFE, J. DIRKSEN: The significance, diagnosis, and treatment of maternal hypovolemia as associated with fetal/maternal illness. Sem. in Peri. 5 (1981) 163
[3] GAUER, O. H., J. P. HENRY: Circulatory basis of fluid volume control. Physiol. Rev. 43 (1963) 423
[4] EPSTEIN, M.: Renal effects of head-out water immersion in man: implications for an understanding of volume homeostasis. Physiol. Rev. 58 (1978) 529
[5] BAZETT, H. C., S. THURLOW, C. CORWELL et al.: The diuresis caused by warm baths, together with some obervations in urinary tides. Am. J. Physiol. 70 (1924) 430
[6] EPSTEIN, M.: Letter to Editor. NEJM (1983) 1030
[7] KASS, D. A., M. C. MOORE-EDE: Renal responses to prolonged central volume expansion in conscious primates. Am. J. Physio. 242 (1982) F689
[8] ARBORELIUS, M., U. I. BALLDIN, B. LIJA et al.: Aerospace Med. 43 (1972) 592
[9] LEVINSON, R., M. EPSTEIN, M. A. SACKNER et al.: Comparison of the effects of water immersion and saline infusion on central haemodynamics in man. Clin. Sci. Mol. Med. 52 (1977) 383
[10] KHOSLA, S. S., A. B. DU BOIS: Osmoregulation and interstitial fluid pressure changes in humans during water immersion. Am. J. Physiol. 241 (1981) 686
[11] KRASNEY, J. A., R. PENDERGAST, E. POWELL et al.: Regional circulatory responses to head-out water immersion in anesthetized dog. Am. J. Physio. 242 (1982) 1625
[12] ZUCKER, I. H., J. P. GILMORE: Responsiveness of type B atrial receptors in the monkey. Brain Research 95 (1975) 159
[13] NEMEH, M., J. GILMORE: Natriuretic activity of human and monkey atria. Circul. Res. 53 (1983) 420
[14] BENNETT, E. D., D. TIGHE, W. WEGG: Abolition by dopamine blockade of the natrueretic response produced by lower body positive pressure. Clinical Science 63 (1982) 361
[15] GOFF, L. G., H. F. BRUBACH, H. SPEDTH et al.: Effects of total immersion at various temperatures on oxygen uptake at rest and during exercise. J. Appl. Physiol. 9 (1956) 59
[16] MCBRIDE, G.: One caution in pneumatic antishock garment use. Medical News. JAMA 247 (1982) 1112

Robert C. Goodlin, M.D.
Department of Obstetrics and Gynecology
University of Nebraska
Medical Center
Omaha, Nebraska 68105
USA